



Hydraulic Innovations

Systems, Subsystems, and Components

Hydromechanical | Electromechanical

- aerospace
- climate control
- electromechanical
- filtration
- fluid & gas handling
- hydraulics
- pneumatics
- process control
- sealing & shielding



ENGINEERING YOUR SUCCESS.

Parker's promise:

Parker's promise:

As the global leader in motion and control technologies, we promise to partner with you to increase your productivity and profitability. Above all, we promise to do whatever it takes to make your program a success.

Our commitment and loyalty to your company and your program are backed by the strength that comes from years of knowledge and experience.

Helping your program succeed is our primary goal. We welcome the opportunity to work with you toward that end.



ENGINEERING YOUR SUCCESS.

Beyond convention. Beyond expectation.

As the world leader in fully integrated hydraulic systems and advanced hydromechanical and electromechanical subsystems and components, the Parker Aerospace Hydraulic Systems Division (HSD) leads the way. We go above and beyond to provide real value for competitive advantage in both commercial and military aerospace applications, as well as land-based mobile vehicles.

Working with our customers, we make it our business to improve productivity and profitability by addressing the issues of safety, performance,

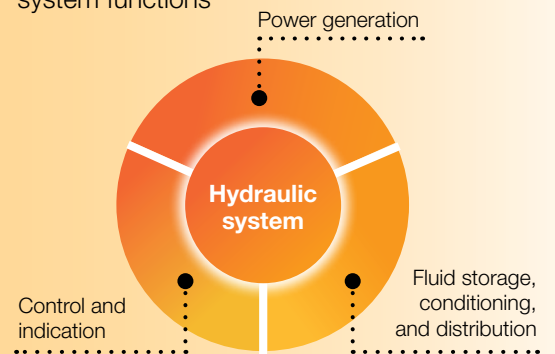
weight, and reliability. From design and development through integration, manufacture, certification, and lifetime support, we work hard to engineer your success, contributing innovative thinking and significant process improvements every step of the way.

As a division of Parker Aerospace and part of the Parker Hannifin family, we have the talent, infrastructure, and resources you need to go forward.

Responsibly. Reliably. Cost effectively.

Hydraulic systems products

Parker HSD provides the full range of hydraulic system functions



One global operation

With a singular ability to provide more responsive local service

We've expanded our operation globally in 11 key countries to support major aerospace centers. Having one global face offers significant advantages for our worldwide customer base.



Hydraulic Systems Division
World Headquarters
Kalamazoo, Michigan

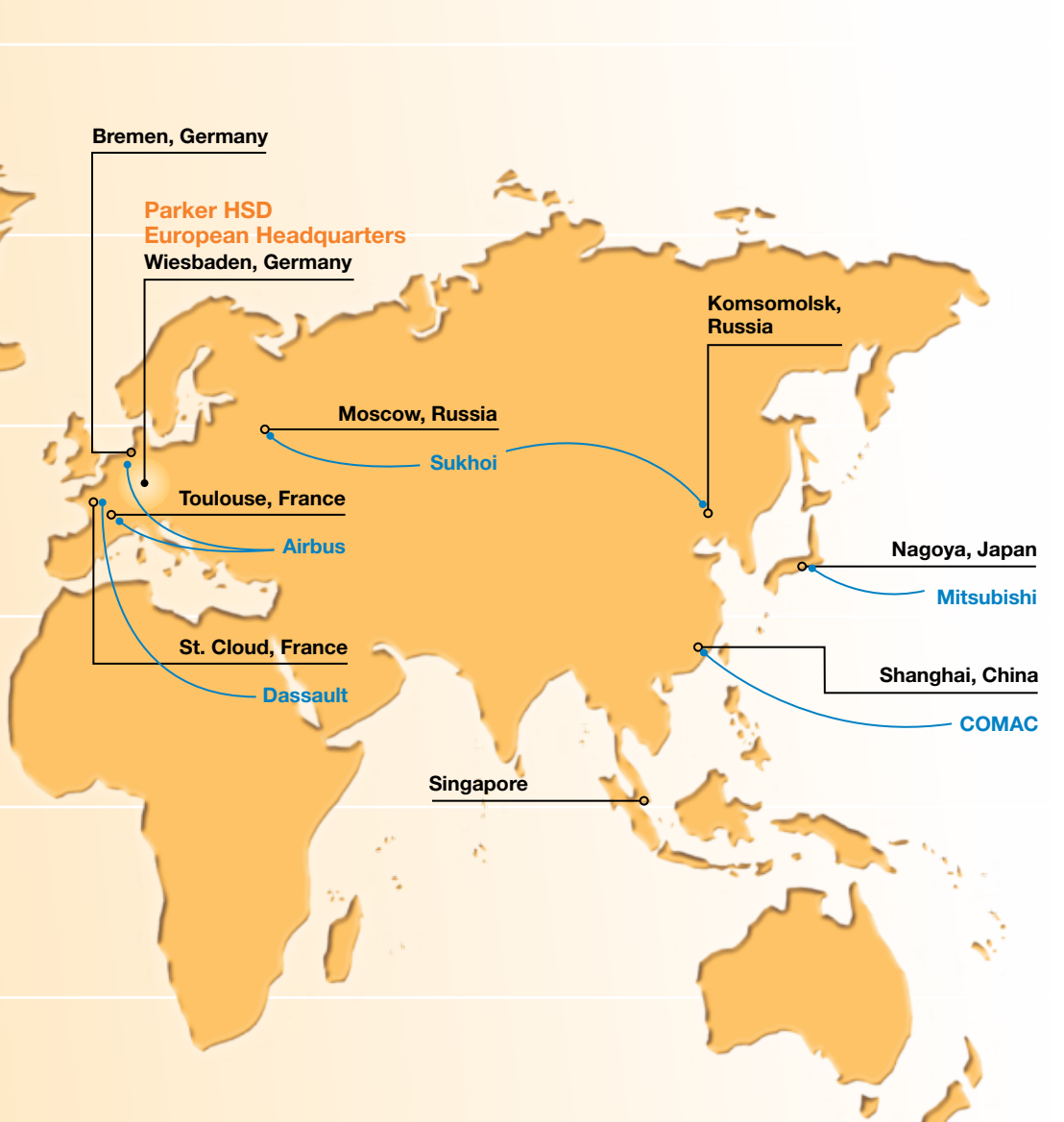
Global means local. The global Hydraulic Systems Division combines the extensive resources of our Kalamazoo, Michigan, and Wiesbaden, Germany, organizations, giving us a singular ability to be more responsive to worldwide customers through local service. This also enables us to leverage engineering resources across programs and to better define, build, integrate, deliver, and support industry-leading hydraulic systems and subsystems for the global aerospace market.



Hydraulic Systems Division
European Headquarters
Wiesbaden, Germany

Affordable global supply. Our multinational structure provides significant global supply chain synergies. Through long-term relationships with key suppliers, HSD has assembled a global network of subcontractors that can provide excellent quality at competitive costs. By emphasizing process stability along with continuous improvement and implementing lean manufacturing, our global operation can consistently offer customers a global supply chain capable of meeting the toughest performance and cost expectations.





ACE Services:
Another Parker first

Parker Aerospace has scored a service ace with ACE Services, a 30,000-square-foot MRO facility located in Singapore.

Specializing in hydraulic pumps, flight control actuators, and thrust reverser actuators, ACE Services is the first aftermarket hydraulic service center in the world capable of 5,000-psi service, which enables it to support new Airbus A350 XWBs and Boeing 787s in service in the region.

In addition, ACE Services provides critical maintenance, repair, and overhaul services for hydromechanical equipment manufactured by Parker as well as other aerospace companies. It is the primary in-region facility providing original-equipment MRO support of Parker systems and components. The bottom line? Faster hydraulic MRO, local support, and OEM-quality parts and service for all Asia Pacific carriers.



Hydraulic systems for tomorrow's aerospace market

Working as a tier-one team leader, **we offer system-level architecture and integration responsibility.** Our hydraulic systems experience extends across both commercial and military platforms, and embraces a wide range of industry-changing programs. This experience has taught us how to identify and minimize risks effectively, create better solutions, and add value to both the product and the process.

Whatever it takes. As a risk-sharing partner, we have helped our customers through all critical development stages. Our systems expertise and broad base of proven technology are matched by our willingness to do whatever it takes to get a program up and running, including on-site participation wherever necessary. We have developed our own high standards and expertise traditionally conducted by the OEM, including:

- Requirements definition and verification
- System architecture development
- System static and dynamic analysis
- System integration testing
- Software and electronics development
- Test rig integration
- Flight testing and certification
- Subcontractor management
- Program management

Broader, deeper experience

Since 1993, 80 percent of the world's major aerospace hydraulic systems have been awarded to Parker Aerospace



1993/1998
Bombardier Global Express



1995/1999
Bombardier Dash 8/Q400



1999/2004
Embraer 170



1999/2005
Embraer 190/195



2001/2006
Dassault Falcon 7X



2002/2005
Bombardier Global 5000



2006/2009
Sukhoi Superjet 100



2008
Airbus A350 XWB

The end result?

Shortened development time and maturity at entry into service.

Program after program after program.

KEY

Aircraft launched/Aircraft entry into service



1997/2000
Bombardier CRJ700



1999/2004
Bombardier Challenger 300



2000/2002
Bombardier CRJ900



2000/2002
Bombardier CRJ900



2002/2008
COMAC ARJ21



2004
Boeing 787



2008
Embraer MSJ/MLJ



2008
Bombardier CSeries



2008
Mitsubishi Regional Jet



Worldwide support: Custom fit to your requirements

When it comes to maintenance, repair, and overhaul we continue to be at the forefront of customer support innovation through Parker Aerospace, Customer Support Operations (CSO). CSO offers a full spectrum of services and support and will work in partnership with you to develop comprehensive programs tailored to fit your specific maintenance and aftermarket needs.

Staffed by a global network of highly trained and dedicated professionals, CSO delivers customer support and logistic services such as 24/7 AOG and technical support. Additionally, we offer value-added services: repairs, inventory management, rotatable exchanges, warranty administration, and technical publications, to name a few.

Local in more locales

Parker Aerospace customer service centers and business offices are strategically located in Europe, North America, Latin America, the Middle East, and Asia Pacific to serve you in your time zone.

PHconnect

Parker's Customer Support Operation offers registered MRO users access to our secure and personalized website. You can view your parts and order data, and access technical publications, component maintenance manuals, and service bulletins 24 hours a day, seven days a week. Visit us at www.phconnect.com.

Systems integration

A six-step process resulting in improved efficiency, lower design and development cost, and enhanced performance

STEP 1 Listen

- Understand the aircraft value proposition
- Work together to define system goals and objectives

STEP 2 Define

- Define the system architecture
- Conduct trade studies
- Produce schematics
- Conduct system performance analysis
- Design, develop, and qualify components

STEP 3 Integrate

- Mechanical and electrical interface integration
- Electronic controls and code/software development
- System installation and spatial integration
- Component design verification

STEP 4 Validate



- Component development and qualification testing
- System integration rig testing
- Reliability, maintainability, and system assessment
- Flight test support
- FAA / EASA / ANAC / TC regulatory agency support

STEP 5 Deliver



- Hardware
- Software and version updates
- Certification documentation
- Product support and technical publications
- Maintenance and fault isolation training

STEP 6 Support

- Maintenance manuals
- Training
- 24/7 repair, overhaul, and engineering services
- Customized options that reduce life-cycle costs
- Continual monitoring through reliability-trend analysis



Parker Aerospace hydraulics power a broad range of narrow- and wide-body commercial aircraft, with systems and subsystems on programs that include the Airbus A350 XWB, Boeing 787, Bombardier CRJ 700/900/1000, CSeries and Q400, COMAC ARJ21, Embraer 170/190/195, Mitsubishi Regional Jet, and Sukhoi Superjet 100.

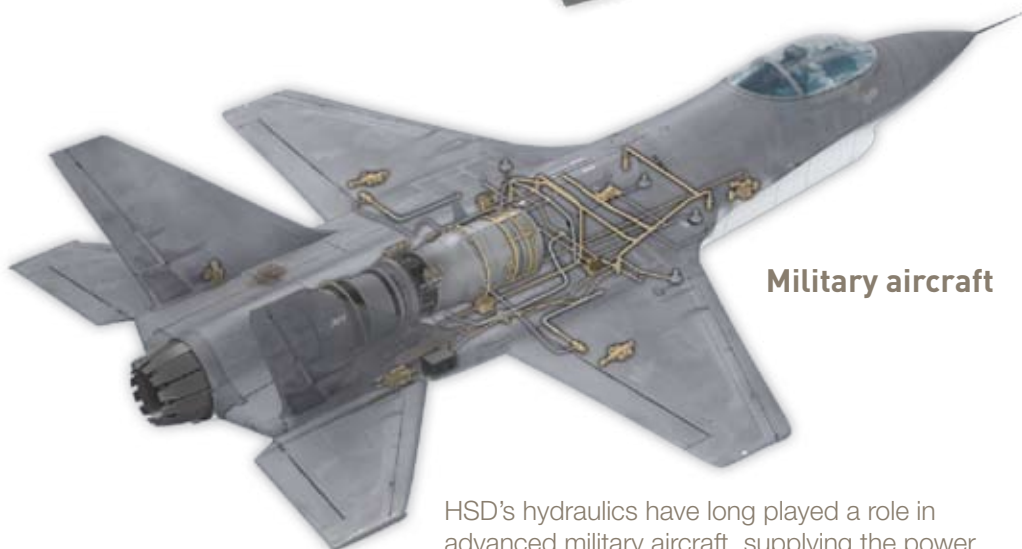
Business aviation



Since 1993, Parker has certified four business jet hydraulic systems, with more underway, helping to lead aviation into the 21st century. Programs include the Bombardier Global Express, Global 5000, Challenger 300, and Dassault Falcon 7X.



Commercial and regional transports



Military aircraft

HSD's hydraulics have long played a role in advanced military aircraft, supplying the power and control needed for helicopters, fighters, transports, and missiles, including the Joint Strike Fighter and UAV programs.



Virtual advantages: Software and control electronics

Our software and control electronics expertise is a core competency for HSD. We assume complete responsibility for defining the logic, and writing and verifying the code to be implemented within an aircraft's electronic or software systems for all hydraulic system controls, as well as for annunciation and maintenance. From logic diagrams and firmware to fully integrated hydraulic control electronics and software integration and certification, we streamline the process, providing excellence under even the most aggressive development schedules.

CMMI certification

To further increase our capabilities in the area of software development, we have achieved CMMI Level 3 certification approval by the Software Engineering Institute (SEI). **The certification makes Parker HSD part of an elite group of world-class software engineering organizations.**

For more information on CMMI, see page 15 of this brochure.



ARJ21 hydraulic system control module

Hydraulic power generation products

With hundreds of applications in commercial and military aerospace markets as well as those in marine and defense

F-35 HP electrohydraulic power module



ELECTROHYDRAULIC POWER MODULES

- Designed for high acceleration reversals and low leakage
- From 0.1 to 0.6 in³/rev displacement
- Variable operating pressure up to 4,000 psi
- Liquid- and fan-cooled motor design, 270 BLDC and 28V
- Provides fluid power for vehicle hydraulic systems
- Power and drive electronics
- Flows up to 26 GPM and speeds up to 20,000 RPM
- Can be supplied with related motor control electronics



787 5,000-psi engine-driven pump

HYDRAULIC PUMPS

- Variable and fixed displacement axial piston pumps provide fluid power for vehicle hydraulic systems
- From 0.03 to 5.5 in³/rev displacement and operating pressures from 1,000 to 8,000 psi
- Superior power-to-weight ratio
- Advanced bearing technology
- Optional features include attenuation, depressurization controls, clutches, case drain, and inlet charge pumps

Power transfer unit



HYDRAULIC POWER TRANSFER UNITS

- Reversing and non-reversing
- Hydraulic power transferred between isolated hydraulic systems
- Increased vehicle system redundancy and reduced failure modes and effects, lower weight system solutions
- Flows up to 28 GPM

767 hydraulic power supply



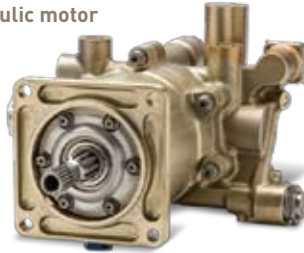
HYDRAULIC POWER SUPPLIES

- Local fluid power supply for various vehicle control and utility functions
- Incorporate system functions such as fluid storage, filtration, control, and indication into one compact package

Airbus family electric motor-driven pump



F-35 gun drive hydraulic motor



ELECTRIC MOTOR-DRIVEN HYDRAULIC PUMPS

- Highly integrated and optimized
- Utilizes various electric motor architectures, including:
 - Fixed or variable frequency AC motors
 - Air- or fluid-cooled motors
 - Brush and brushless DC motors
 - 28V DC and 270V DC motors
- Power and drive electronics

HYDRAULIC MOTORS

- Variable- and fixed-displacement axial piston motors
- Provide rotary power for:
 - Flight controls
 - Winches
 - Landing gear kneeling and steering
 - Wing-folding
 - Fuel pod hose reels
 - Electrical generators
 - More
- Torque capability up to 1,200 inch-pounds



High-efficiency electric motor-driven pumps

Parker HSD's enhanced capabilities of in-house electric motor design/manufacturing and power/drive electronics allow us to be more responsive to the marketplace, and to be in lock-step with the continued evolution of more-electric systems architectures and configurations.

We have the design flexibility to offer a variety of options that will meet or exceed system and component power, cooling and envelope/mounting functions, and feature requirements. Our technical specialists manage all areas of the product life cycle and are uniquely positioned to balance the constraints of cost, schedule, and performance, assuring the most optimized solution for each application.

Bottom line: our significant heritage in hydraulics coupled with our expanded electric motor design and power/drive electronics expertise means that we can reduce system and component energy inefficiencies. The result: a more fuel efficient aircraft that benefits both operators and the environment.



Helping Sukhoi systematize success on the Superjet 100

A 75- to 95-seat regional aircraft, the Sukhoi Superjet 100 is key to Russia's commercial airline modernization program. As the lead supplier of the hydraulic system, we have design and integration responsibility for the complete package, including power generation, electronic control, and fluid conveyance.

Parker Aerospace has leveraged the experience and resources of several divisions to supply distribution and inerting systems for our customer.

Actuation and utility products

Meeting stringent weight, envelope, and performance requirements



Valves

VALVES

For fluid power control, system synchronization, safety, and maintenance:

- **Solenoid-operated valves:** usable alone or in a larger component
- **Hand-operated valves:** for safety overrides using mechanical linkages to shut off or redirect hydraulic fluid
- **Sequencing valves:** control the order of events to prioritize operation of flight-critical users
- **Pressure-reducing valves:** controlling the pressure levels within a system
- **Pressure relief valves:** protecting systems from overpressure
- **Fill select valves:** provide filling of multiple systems from a single point



787 HP filter module

FILTER MODULES

- Filters, valves, and sensors integrated into a single manifold
- Facilitate system pressure monitoring
- Differential pressure indicators allow for timely filter replacement
- With relief valves, prevent system overpressure
- With check valves, ensure proper flow path
- Different materials available to optimize cost and weight
- Critical to a functioning system
 - Safeguard against contaminants
 - Bowl eliminates improper installation
 - Automatic bowl shutoff prevents leakage

777 main gear steering unit



LANDING GEAR ACTUATION AND STEERING CONTROL SYSTEMS

- Fully integrated multi-actuator systems that control the deployment and actuation of the aircraft landing gears, including the nose landing gear steering
- Linear actuators
 - Provide forces up to 35,000 lbs.
 - Operate routinely in both 3,000 psi and 5,000 psi hydraulic systems
 - Perform in temperatures from -65°F to 275°F



A330 thrust reverser actuation system

THRUST REVERSER ACTUATION SYSTEMS

- Multi-actuator system that redirects the exhaust gas flow, decelerating the aircraft
- Synchronized by a shaft and worm gear system
- Incorporates filters, valves, and hydraulic lines
- Completely customizable



Accumulators

PISTON-TYPE ACCUMULATORS

- Designed to meet stringent weight, envelope, and performance requirements
- Optional single-end caps and/or Kevlar® wraps for increased weight performance
- Many tested to exceed military specs for endurance, impulse, and vibration
- Offer high endurance with the capability to withstand high pressure fluctuations



Aft strut fairing module for the 787

As a tier-one system integrator and risk-sharing partner with Boeing on the 787 program, we took the lead to provide an innovative approach to modularization. Working with other 787 partners, we pre-integrated 60 major components plus hundreds of structural elements and fasteners into a single deliverable module. This turn-key module is pretested as a subsystem and engineered to interface the wing for quick installation to the airplane. The aft strut fairing module consists of:

- Major frame assemblies
- Hydraulic power generation components
- Hydraulic hose, fittings, and tubing elements
- Electrical wires, harnesses, and connectors
- Secondary mounting brackets and fasteners

FULLY INTEGRATED STRUCTURAL AND MODULAR SYSTEMS

- Complex pre-integrated subsystems reduce aircraft production flow time
- Combine numerous pre-integrated components with high-level supply sources such as:
 - Structural frame assemblies
 - Utility hydraulic products
 - Hydraulic fluid conveyance
 - Electrical wiring and connectors
 - Mounting equipment and hardware
- Teaming with other partners and sub-tier suppliers, Parker Aerospace assumes full system responsibility, including:
 - Requirements definition
 - Design
 - Build
 - Conformity
 - Qualification
 - Functional testing



787 bootstrap reservoir

BOOTSTRAP RESERVOIRS

- Standard, stand-alone units or highly customized, fully integrated units with filtering, control, pressure maintaining, bleed, and sensing technology
- Many with line-replaceable units, including:
 - Visual and electrical level sensors
 - Pressure and temperature sensors
 - Filter replacement indicators
 - Overboard relief valves
 - Isolation valves
 - Manual and automatic bleed valves

Auto bleed valve

Our auto bleed valve provides automatic detection and bleeding of air in a hydraulic system. This Parker Aerospace proprietary technology offers the advantage of maintenance-free air management of air and oil systems while preserving the benefits of a closed system for improved performance. The device is typically mounted directly to the reservoir as a line-replaceable unit and may be controlled through the aircraft's computing system.

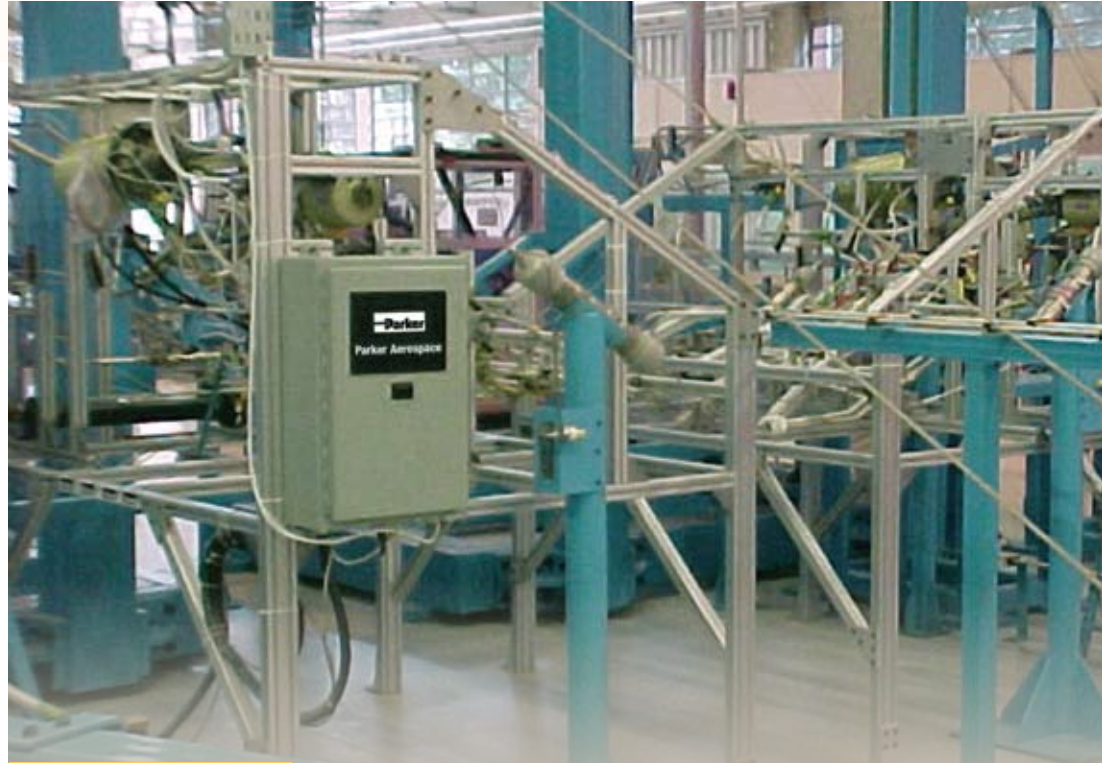


Technical expertise

Mitigating risk. Innovating excellence.

Testing

Parker HSD offers its customers the advantages of more than a decade – and tens of thousands of hours – of in-depth system rig and aircraft ground and flight test experience.



Iron bird rigs

Our experts begin by defining the types of system tests that are to be performed on customer test rigs. We then perform complete systems testing, correlating our analysis results with ground and flight test results. Our fully automated iron bird rigs include complete hydraulic systems integrated with landing gear, steering, brakes, flight controls, and thrust reverser systems, duplicating actual aircraft conditions as closely as possible for accurate results. Notable programs that Parker has supported with iron bird testing include the Bombardier Global Express, CRJ700, Q400, and Challenger 300, as well as the Dassault Falcon 7X and the Embraer regional jets.



Working closely with Dassault engineers, we simplified the hydraulic system on the 7X, resulting in a 40-percent weight reduction from the original concept. The hydraulic test rig and its control panel at Parker's facility were critical to the process.





Sophisticated robotic manufacturing is just one way that Parker HSD boosts quality and lowers cost.

Aircraft ground and flight testing

Parker Aerospace also has significant experience supporting on-site flight testing. We routinely perform both ground tests and flight tests to demonstrate system performance and compliance with airworthiness regulations. Parker Aerospace engineers define the tests to be performed, and assess and report the results. Tests commonly performed include the following:

Ground tests

- Pump startup and shutdown
- Reservoir mapping, high and low level
- High-pressure operation
- Pump pressure ripple

Flight tests

- Mission profile and pressure transient survey
- Pump failures and backup operation (including RAT operation)
- Vibration survey
- System high and low temperature

Technology and engineering

With the ability to solve your most difficult technical challenges, Parker HSD is well known and respected for its technology and engineering expertise. Our multi-disciplinary teams combine proven processes and technology with innovative

thinking to minimize complexities and risk, lowering cost and speeding time to market. Their work is complemented by:

- A complete portfolio of analytical design tools, including ANSYS Workbench, AMESYM, SIMULINK, NASTRAN, OPTI-STRUCT, EASY 5, CATIA, and Parker Computational Fluid Dynamics (CFD) software
- Advanced dynamic modeling, stress, vibration, and thermal simulation, and flow-performance studies to increase efficiency and total quality from the start of a project
- A 48,000-square-foot engineering test lab for the development, acceptance, and qualification testing of aerospace components
- A systems integration lab
- An engineering model shop enabling rapid prototyping of even the most complex parts



Our advanced 3-D printer capability enables rapid prototyping of even the most complex parts.



SpiritWorks:

HSD's research and development arm

A group of innovative engineers charged with pushing the performance envelope, SpiritWorks was formed to identify, investigate, and develop emerging technologies.

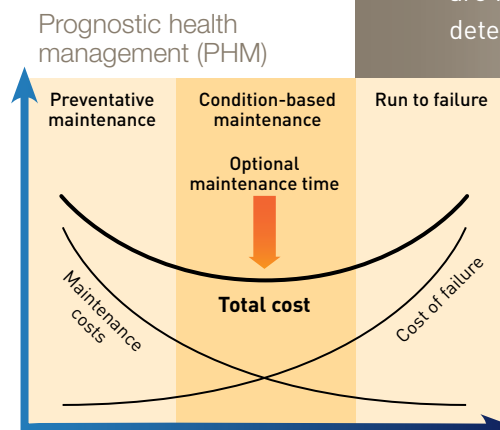


These out-of-the-box thinkers look at hydraulic power systems in different ways to create the motion control technology of tomorrow. Like Parker's "Winovation" program, the collaborative idea-generator for the corporation, SpiritWorks is based on the principles of Stage-Gate®, a step-by-step business system that drives the commercialization of R&D efforts.

Prognostic health management

Through our SpiritWorks operation, Parker Aerospace engineers are working with customers to determine how advanced sensor

technology and predictive modeling can provide prognostic health management to the aircraft hydraulic system. By actively monitoring the system, PHM can increase the reliability of the system by reporting the remaining life of key components.



Process management

Improving performance, increasing speed to market, reducing costs

A program management process that's by the book

Specifically the PMBOK® Guide, a lexicon on the practices of project management as defined by the Project Management Institute (PMI®), recognized worldwide as a pioneer in the field. Understanding that an efficient, consistent, and standardized process is critical to program success, we apply our Program Management Process (PMP) to maximize performance and minimize lead time. The PMP uses the nine major knowledge areas of PMBOK to fit our aerospace industry and products. These include:

- **Integration management:** resulting in an integrated program plan
- **Scope management:** ascertaining the work required to complete the project successfully
- **Time management:** what needs to be done to achieve timely completion
- **Cost management:** planning, estimating, budgeting, and controlling costs with the established budget



- **Quality management:** assuring that the project will satisfy the objectives for which it was undertaken
- **Human resource management:** organizing and managing the project team
- **Communication management:** the timely generation, collection,

- dissemination, storage, and disposition of relevant information
- **Risk management:** the processes concerned with conducting risk management on a project
- **Supply chain management:** relating to the purchase or acquisition of products and services

Lean Product Development



In committing to structured processes and established methodologies, we ensure our successful management of cost, scope, and time constraints on every program. We also employ a balanced organization and empower our program managers with the proper authority to ensure that each program has the highest visibility to both internal and external stakeholders. This makes certain that when problems arise, we are moving forward with swift corrective action to keep the program on track through each phase of the project life cycle.

Standard design and development process

Conducted in concert with the program management process (PMP), the standard design and development process (SDDP) is our proprietary group development process. It identifies the high-level activities, inputs, and dependencies, completion criteria, and best practice examples for a specific program's design and development process, from bid and proposal through complete entry into service.

With a project gate review checklist that is segmented into eight stages for each product offering, SDDP ensures that activities are performed and deliverables are reviewed and approved at each stage of the development process. SDDP's standard methodology also encourages completeness while minimizing waste as part of HSD's commitment to lean product development.

CMMI certification

With its recent achievement of CMMI Level 3 certification, Parker HSD is now part of an elite group of world-class software engineering organizations. To reach this level, the HSD software team had to align its business processes with 18 CMMI-required areas. These process areas can be broadly categorized into project management, engineering, support, and process management.

Increasingly demanded by our customers, the CMMI model is the global standard of excellence for continuous improvement in product engineering and service delivery. It defines world-class performance and best practices for product development, creating processes that serve as a baseline for conducting independent appraisals of organizational capability and maturity. We are now applying CMMI processes for the commercialization of software for the control, indication, and health management of hydraulic systems aboard the next generation of commercial aircraft including the 787 and A350 XWB.

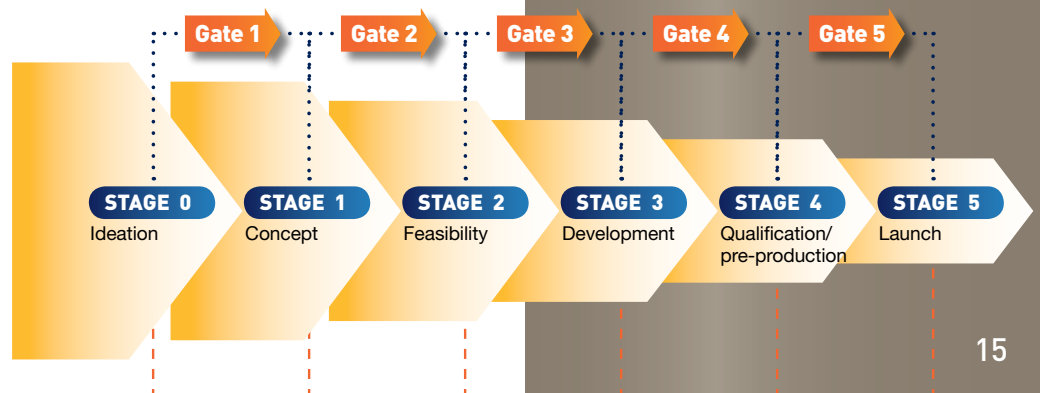
With milestone reviews, objective process and work product reviews, and stakeholder involvement throughout the product development life cycle, CMMI integrates seamlessly with SDDP and harmonizes well with our corporate-wide commitment to lean.



Winovation: Identifying unmet customer needs

Parker Hannifin Corporation's Winovation process is a business system for driving excellence in the development of new products and services that fulfill unmet customer needs. Based on the principles of Stage-Gate®, a step-by-step business system that drives the commercialization of R&D efforts, the process gets Parker decision makers to take new product ideas through five stages of deliberation, producing a focused value proposition with unique customer benefits and a differentiated solution. The process relies heavily on strong market and voice-of-the-customer inputs.

Winovation process



Turn to Parker HSD to engineer your success

Working together, we make it our business to improve your productivity and profitability by addressing the issues of safety, performance, weight, and reliability. From design and development through integration, manufacture, certification, and lifetime support, we work hard to engineer your success. Contributing innovative thinking and significant process improvements every step of the way.

To find out how our hydraulic innovations can profitably power your programs, contact us at **(269) 384-3400** or visit **www.parker.com**.







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